2011-47-WS

Rebuttal Testimony

Of

Patrick Flynn

Exhibit PCF-1 Misc Charges

CAROLINA WATER SERVICE, INC.'S

RESPONSE TO

OFFICE OF REGULATORY STAFF's

SECOND CONTINUING

INFORMATION REQUEST

2.3 Provide the following information for the Disconnection Charge, $100 Meter Installation Charge, Tampering Charge, and Pumping Charge:
a. Detailed cost justification for water and sewer;
b. Identify the expenses incurred by CWS that support the charge for water and sewer; and
c. Provide the projected amount of revenue to be generated by the charge for water and sewer.

Response: Disconnection Charge

a. The proposed Disconnection Charge is intended to allow the Utility to recover the cost of physically disconnecting a customer who, after being given proper notice as required by rule, fails to make payment of the past due balance in a timely fashion. The Disconnection Charge would include the cost of printing and mailing disconnect notices to the customer; all of the transportation expense incurred to travel to and from the premise by utility personnel; the cost to turn and lock off the water service; and, in the case of a sewer-only, customer, the total cost to install an elder valve on a sewer service where one does not already exist.

b. Expenses to disconnect a water customer include:

Printing and mailing expense (nominal amount)	$ 5.00
Labor cost to visit the premise, take a read, lock off service and post the information in the billing system ($30.00/hour X 0.5 hrs)	$15.00
Meter lock	$ 5.00
Transportation expense, (nominal distance, 20 miles @ $0.50/mi)	$10.00
TOTAL	**$35.00**

Expenses incurred to disconnect a sewer customer include all of the above items plus the actual cost to install an elder valve, which varies greatly depending on various factors including: location and depth of the sewer pipe at the point of connection; video inspection services to determine the location of the sewer tap where it is otherwise not discernable; the cost of materials and supplies needed to install an elder valve; the presence and extent of underground and above ground conflicts such as driveways, sidewalks, trees, fences, and landscaping; the cost of restoration of the work area; and the cost of traffic control equipment and associated services. The total cost of an elder

valve installation can therefore vary from a minimum of $250 to as much as $2,500.

c. Projected annual revenue for water disconnection activity is estimated as the following: 600 disconnects/year x $35.00/disconnect = **$21,000**
The estimated revenue generated for sewer disconnects is estimated as the following: 200 disconnects/year x $500/disconnect = **$100,000**

$100 Meter Installation Charge

a. The actual cost to install a water meter at a premise should be recovered when service is requested. The meter installation charge should increase with meter size to reflect the increased cost of meters and appurtenances as the size of the meter increases and be inclusive of all parts and materials. Water meter specifications for all sizes and applications must meet minimum standards as established by AWWA and the utility based on the type, location and extent of water use; maximum instantaneous demand; and any other pertinent factor that impacts the ability of the meter to accurately and repeatedly measure water use.

b. Labor and materials associated with the installation of a 5/8"x3/4" cold-water meter include:

Standard brass meter housing, local read register, bronze bottom, lead-free alloy material, conforming to AWWA Standard C-700 plus shipping	$50.00
Standard meter box with meter reader lid	$25.00
Transportation expense (20 miles @ $0.50/mile)	$10.00
Labor to install on existing service line, 1 hour @ $30.00/hour	$30.00
TOTAL (A)	**$115.00**
Added cost if Ford meter box is utilized	$100.00
TOTAL (B)	**$215.00**

c. Estimated annual revenue generated from new meter installation activity is highly variable and dependent on a number of factors including: residential development activity; housing construction market conditions; size, suitability and location of unimproved property relatively near existing or proposed utility facilities; and the availability of adequate water and/or sewer capacity to serve additional customers. Therefore, a conservative estimate is based on 200 customers added/year @ $115.00 each = **$23,000**

Tampering Charge

a. A Tampering Charge should be established in order to deter customers from tampering with the operation, maintenance, or repair of a water or sewer service.

b. A Tampering Charge of $250 is proposed as a minimum amount based on tampering charges contained in current tariffs in other states in which Utilities, Inc. conducts business. However, the customer should be held responsible for all actual costs incurred as a result with tampering activities.

c. It is estimated that the Tampering Charge will generate approximately **$3,000** per year based on it being levied once per month @ $250.00 each.

Pumping Charge

a. This charge would be applicable to those sewer customers who utilize a solids interceptor tank, which must be pumped out periodically at the customer's expense. The recommended interval is five years; however, these solids interceptor tanks must be pumped out more frequently in some cases and immediately once a tank becomes full in order to avoid a sewer backup into the home. It is proposed that the customer should bear the actual cost of all pump-out activities including the additional cost of performing this service when it is conducted after normal business hours. In this way, it will be advantageous for the customer to schedule the activity during normal business hours.
b. Actual costs have risen significantly since the pumping charge of $150.00 was first established. The $150.00 charge does not reflect the full cost of performing this service. Currently, actual costs vary from $250.00 to $700.00 depending on the contractor selected and the cost to dispose of the contents in conformance with all regulatory requirements and in an environmentally responsible manner.
c. There are currently approximately 1,015 interceptor tanks in use. It is estimated that 20% of the tanks are pumped annually. At an average cost of $400/pump-out, the annual revenue is estimated to be: **$81,200**

Responder: Patrick Flynn

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Exhibit PCF-2

PURCHASED WATER SYSTEMS AND WATER PROVIDER

STATE	SUBDIVISION	BULK PROVIDER	Customer Count	SFE's
	CAROLINA WATER SERVICE, INC.(CWS)			
SC	Westside Terrace	Town of Lexington	67	67
SC	Rollingwood/Silvercreek	Lexington County Joint Water & Sewer Commission	189	189
SC	The Landings	Lexington County Joint Water & Sewer Commission	164	164
SC	Harborside / Harbour Place / Windward Pt.	Lexington County Joint Water & Sewer Commission	98	98
SC	Lands End/Watergate / Spences Pt. / Mallard Shores	Lexington County Joint Water & Sewer Commission	332	358
SC	Idlewood Drive	City of West Columbia	71	71
SC	River Hills	York County	3952	4261
SC	I-20 AREA (CWS)	City of West Columbia	2341	2330
	which includes the following subdivisions:			
	Sycamore Acres		82	82
	Oakwood		71	71
	Laurel Meadows/Savannah Point /Agape Village		315	315
	Brighton Forest		141	136
	Spring Lake / Dutchwood		126	122
	Spring Hill/Oakcrest/Timbergate/Meadowood/Mineral Creek/Maple Grove/Cunningham Park		463	451
	Planters Station/Keystone Commons/Bradford Estates		168	165
	Grayland Forest/Woodcastle/Sparrow Point		316	310
	Golden Pond/Woodberry Forest/Sommersett		358	354
	Oak Grove Est/Courtside Commons		236	259
	Hidden Valley MHP		65	65

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Exhibit: AWWA-State Survey 2002

SURVEY OF STATE AGENCY WATER LOSS REPORTING PRACTICES

FINAL REPORT TO THE AMERICAN WATER WORKS ASSOCIATION

January 2002

Prepared by
Janice A. Beecher, Ph.D.
Beecher Policy Research, Inc.

SURVEY OF STATE AGENCY WATER LOSS REPORTING PRACTICES
FINAL REPORT TO THE AMERICAN WATER WORKS ASSOCIATION

January 2002

Prepared by
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Introduction[1]

There might have been a time when having a fair amount of lost or "unaccounted-for" water was pretty acceptable to water utilities. Finding and plugging leaks might not have seemed cost effective for a typical water system; that is, the perceived cost of detection and repair might have outweighed the perceived benefits of saving water. Many water systems also might not have metered or charged for certain kinds of uses.

Such practices are no longer accepted as the best management of water resources. Today, the commodity that water systems deliver has greater value than ever before. Extraction, treatment, storage, and pumping all add value to the water resource. Ignoring the value of water losses is no longer justifiable.[2] Given growing constraints on water resources and mounting infrastructure costs, it is more imperative than ever that water managers endeavor to account for the water that travels from the source to end users.

While lacking a rational structure for quantifying water loss, numerous assessments in the literature suggest that water loss is a significant, and often overlooked, occurrence for many US water utilities. Many case studies have documented systems for which losses from leakage and poor accounting constitute substantial portions of total water deliveries.

A growing number of communities are faced with pressure to find additional supplies to serve expanding populations. Many of these exist in water-limited regions where the development of new supply sources and the allocation of existing sources are complex and sensitive issues. Yet rational assessment of water-loss performance and appropriate improvements often are not pursued as a resource management option or given appropriate priority.

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[1] Based on George Kunkel and Janice A. Beecher, *Survey of State Agency Water Loss Reporting Practices: Preliminary Findings.* Proceedings of the 2001 AWWA Annual Conference (Denver: CO: American Water Works Association, 2002).
[2] George Kunkel, "Cutting Our Losses," *Journal AWWA* (January 2001): 40.

Proper management of any resource must include accurate measurement of the resource throughout its life cycle. In any proper accounting system checks and balances must be provided via the use of independent audits, consistent reports and rational procedures. U.S water systems do not consistently account for water or apply consistent methods of water accounting. The need for a reliable and authoritative system of water accounting has become increasingly apparent to utility managers and practitioners in the field of water-resource policy.

This paper describes the findings of a research project sponsored by the Technical and Educational Council of the American Water Works Association that provides an initial baseline of data describing the status of water accounting and related public policy at the state and regional levels. The results are summarized in this paper and the detailed findings by jurisdiction are available in a spreadsheet format.

Water Accounting

Many water providers in the United States refer to the term "water accountability" as the measure of effectiveness in moving their product (water) to their customers with minimal losses in transmission and distribution. Water accountability, however, is not a well-defined discipline and the methodologies used to quantify losses are varied and inconsistent. Lack of standard terminology and measures are at the center of the water-loss penumbra.[3] Often quoted, but poorly defined, the "metered-water ratio" more frequently confuses rather than informs the reader when attempting to evaluate the water loss condition of suppliers.

Confusing terms and standards can make it difficult for water professionals to address water-loss issues. The terminology used to represent the difference between the water that is withdrawn from the source and water that is eventually distributed to end users is imprecise. For example, the terms "water losses" and "unaccounted-for water" have been used somewhat interchangeably. But not all unaccounted-for water is lost; some might be given away or used for authorized purposes. Some water has been labeled "nonrevenue" or "nonrevenue producing" but such water might include both authorized and unauthorized uses.[4] EPA has used the term "uncompensated usage" to include water used by public authorities, water used for maintenance purposes (flushing), leakage, and uncollected accounts from customers.[5]

In a 1987 study for the American Water Works Association Research Foundation (AWWARF), a useful distinction was made between "account" and "nonaccount" water: *Account water* is all water for which an account exists, the water is metered,

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[3] Ibid.
[4] Janice A. Beecher and Patrick C. Mann, *Cost Allocation and Rate Design for Water Utilities* (Columbus, OH: The National Regulatory Research Institute, 1990).
[5] U.S. Environmental Protection Agency, *Community Water System Survey* (Washington, DC: USEPA, 1997).

and the account is billed: *nonaccount water* is the sum of all water produced or purchased by a water utility that is not covered by the term "account water."[6]

This proposed nomenclature has not been widely internalized by U.S. water systems. For the most part, the industry and state agencies tend to use the term "unaccounted-for water" to mean leaks as well as other kinds of avoidable losses relative to total water production. However, the measurement of unaccounted-for water can be a source of confusion because the numerator and the denominator used to calculate the percentage are not obvious. Is the percentage amount supposed to represent all water not metered and sold or only water lost through leaks? How the percentage is calculated is obviously meaningful.

The confusion about terms exacerbates the confusion about standards. Any single standard (expressed in terms of volume or a percentage) for unaccounted-for water may not be valid, realistic, or appropriate for a particular water system. Many system characteristics—such as size, age, service population density, physical terrain, soil characteristics, and pipe materials—will affect leakage rates. Systems also have different production-cost profiles against which the cost-effectiveness of leak detection and control programs can be evaluated.

In 1996, AWWA's Leak Detection and Accountability Committee recommended 10 percent as a benchmark for unaccounted-for water, supplanting a 15 percent standard that apparently was based more on folklore than rigid empirical analysis.[7] But even this 10 percent recommendation in considered arbitrary in nature and the use of any percentage loss indicator is now viewed as suspect; particularly in light of emerging approaches that rest on more accurate water accounting.

The AWWA Committee concluded that, "Regardless of the water system's size, water loss should be expressed in terms of actual volume, not as a percentage."[8] This volumetric measure, the committee points out, is essential for estimating the monetary value of losses. The volumetric measure of lost water can be multiplied by the unit cost of water production (or the retail rate) to estimate the value of the lost water. From an economics perspective, the true value of losses is the *marginal* or *incremental* unit cost of production (that is, the cost of producing the next increment of drinking water supply). Incremental or marginal costs more accurately reflect water's resource value, which will increase as supply alternatives become scarcer. Reducing leakage and loss can help systems capture a supply resource and avoid costly supply-side operating and capital costs.

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[6] Lynn P. Wallace, *Water and Revenue Losses: Unaccounted for Water.* Denver, CO: American Water Works Association, 1987.
[7] AWWA Leak Detection and Water Accountability Committee, "Committee Report: Water Accountability," *Journal AWWA* (July 1996): 108-111.
[8] Ibid., 110.

Although widely applied, the concept of "unaccounted-for water" is troubling from a best-practices perspective, as well as from perceptual viewpoint; professional water managers should be able to "account for" their inventory using appropriate measurement and estimation tools. Recently a task force of the International Water Association (IWA) created a new methodology and set of performance indicators for water loss.[9] These measures, which can be applied internationally, recommend against the use of the term "unaccounted-for" water, based on the premise that *all* water should be accounted-for, as either a use or a loss. Most analysts agree a better system of *accounting* is the foundation for a better system of *accountability* for the drinking water supply industry.

Goals of the Project

The major goal of this project is to determine the extent to which state and regional agencies have established politics related to water loss and water-loss management. By making a comprehensive and systematic assessment of current policy, the project will help establish a baseline of understanding that can be used to evaluate the validity of the widely held perception that greater consistency is needed in water accounting for U.S. water utilities.

Approach

A survey was designed for completion by any state agency that might play a role in establishing or implementing a policy regarding water losses. State agencies that were contacted included drinking water administrators, natural resource agencies, and public utility regulatory agencies. Regional (multistate and substate) agencies, such as the Delaware River Basin Commission and the Florida water management districts (respectively), were also surveyed on a limited basis. A copy of the survey is included as Appendix A.

The survey results were supplemented by a document search and a review of state web sites to collect general information on state policies, including, but not limited to state laws and regulations, definitions, standards, and accounting requirements.

Survey information was gathered from various agencies representing thirty-four states, as well as the Delaware River Commission, the Southwest Florida Water Management District (SWFWMD FL), and the St. Johns River Water Management District (SJRWMD FL) (for a total of 37 completed surveys). Information on water loss policies was acquired for an additional eleven (11) state jurisdictions for which no survey was completed. Accordingly, the study includes information for forty-six (46) jurisdictions, including forty-three (43) states (See Table 1 and Figure 1).

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[9] International Water Association, *Performance Indicators for Water Supply Services* (London: International Water Association, 2000).

Although not entirely complete or representative, the results provide relatively good coverage of state water-loss policy development.

Table 1
State Water Loss Policy Survey Coverage (December 2001)

State or Regional Government	Survey	Other Information Sources
Alabama		
Alaska	X	
Arizona	X	Web search
Arkansas		
California	X	Document search
Colorado		
Connecticut	X	Web search
Delaware	X	Web search
Florida	X	Web search
Georgia	X	Web search
Hawaii	X	Web search
Idaho	X	2 surveys
Illinois		
Indiana	X	Web search
Iowa	X	Web search
Kansas	X	Web search
Kentucky	X	Document search
Louisiana		Web search
Maine	X	
Maryland	X	Document search
Massachusetts		Document search
Michigan		
Minnesota	X	Web search
Mississippi		
Missouri	X	
Montana	X	
Nebraska	X	
Nevada	X	Document search
New Hampshire	X	
New Jersey	X	
New Mexico		Document search
New York		Web search/Document search
North Carolina	X	Web search
North Dakota	X	
Ohio	X	2 surveys/ Web search
Oklahoma		
Oregon	X	
Pennsylvania	X	2 surveys
Rhode Island	X	
South Carolina	X	
South Dakota	X	

Table 1 (continued)

State or Regional Government	Survey	Other Resources
Tennessee		Document search
Texas	X	Web search
Utah		Web search
Vermont	X	Web search
Virginia		Document search
Washington		Web search
West Virginia		Web search
Wisconsin	X	Document search
Wyoming	X	Web search
Delaware River Basin Commission	X	
Southwest Florida Water Mgmt. Dist.	X	
St. Johns River Water Mgmt. Dist.	X	
TOTAL	37	29

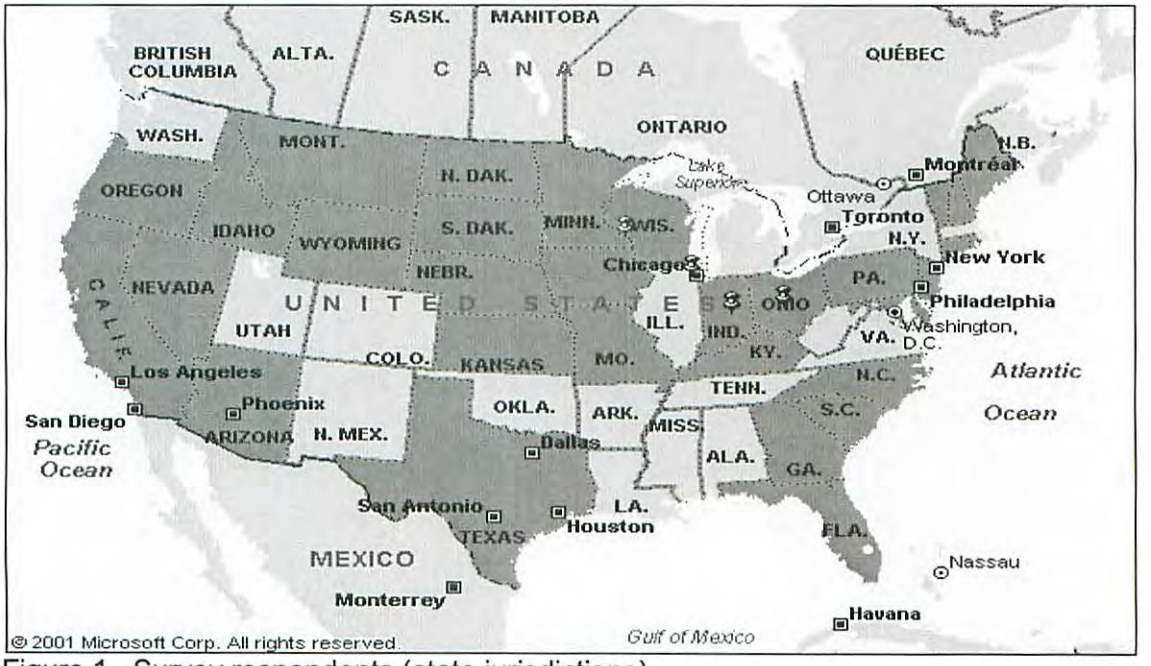

Figure 1. Survey respondents (state jurisdictions).

Survey Design

The survey on state water loss policy, as well as the supplemental research, was designed to be very simple and straightforward in order to ensure a high rate of response. Ten issue areas, which emerged from the preliminary research phase of the project, were covered by the survey:

1. Water-loss policy. Does the state have a policy regarding the loss of water by water utility systems? If so, where is the policy stated (statute, regulation, directive, etc). Which agency or agencies are responsible for implementing the water loss policy?

2. Definition of water loss. Does the state or agency provide a definition of water loss or unaccounted-for water?

3. Accounting and reporting. Does the state or agency provide a method to account for and report water loss?

4. Standards and benchmarks. Does the state or agency identify a standard or benchmark for water losses, such as a specific percentage?

5. Goals and targets. Does the state or agency specify a goal or target for water-loss reduction?

6. Planning requirements. Does the state or agency address water-loss issues in the context of water resource, conservation, or other planning requirements?

7. Compilation and publication. Does the state or agency compile and/or publish data on water losses by water utility systems?

8. Technical assistance. Does the state or agency provide any form of direct technical assistance to water utility systems to help reduce water losses?

9. Performance incentives. Does the state or agency provide any form of performance incentive for water-loss reduction?

10. Auditing and enforcement. Does the state or agency implement any form of auditing or enforcement in relation to the water-loss policy?

Survey respondents were asked to provide additional information for affirmative responses to any of the survey questions. Follow-up contacts with some respondents helped provide additional information as needed.

Finally, in addition to the survey, case studies were developed for six jurisdictions in order to highlight various aspects of water-loss policy development:

- Arizona Department of Water Resources
- Kansas Water Office
- Minnesota Department of Natural Resources, Division of Waters
- Pennsylvania Public Utility Commission and Pennsylvania Bureau of Water Supply and Wastewater Management
- Delaware River Basin Commission (interstate)
- St. Johns River Water Management District (intrastate Florida)

Survey Findings

Water-Loss Policy

Whether a state or agency has a water-loss policy is defined very liberally. Survey respondents were asked to indicate the existence of a policy. However, a policy was also assumed if information was found in any official state document. A water-loss policy can thus range from one that simply encourages utilities to reduce losses to one that specifically defines water loss, sets standards, requires reporting, and enforces compliance. Based on these broad criteria, the presence of a water-loss policy was detected for thirty-three (33) states plus the two surveyed Florida Water Management Districts and the Delaware River Basin Commission (for a total of 36 jurisdictions).

Water loss policies are most commonly found in a variety of state administrative codes, rules, and statutes. State agencies frequently reiterate and emphasize water loss policies in pamphlets, manuals, official forms, and memoranda of understanding. These can be useful information sources for understanding a particular agency's water loss policy.

As expected, the survey results indicate that the agencies responsible for water loss policy vary from state to state. Typically, the agency with responsibility in this area will be the state water resource, natural resource, or environmental agency that has jurisdiction for water-quantity issues. To a lesser extent, some state public utility commissions also implement water-loss policies. Least involved in water-loss policies are the state drinking water administrators, the primacy agencies for water-quality concerns.

Definition of Water Loss

According to the survey, seventeen (17) jurisdictions provide a definition of water loss or unaccounted-for water (including the St. Johns River Water Management District and the Delaware River Basin Commission). For the most part, these definitions do not provide for an operational measurement of unaccounted-for water. Most of the definitions differentiate between metered versus unmetered water. For

example, the Georgia Environmental Protection Division defines unaccounted-for water as "the difference between the total amount of water pumped into the water system from the source(s) and the amount of metered water use by the customers of the water system expressed as a percentage of the total water pumped into the system" (Rules and Regulations of the State of Georgia Chapter 391-3-2-.02 Definitions, Amended).

The California Department of Water Resources distinguishes between authorized unmetered uses and water losses. Authorized unmetered uses may include water used for beneficial purposes, such as fire fighting and main flushing. Most definitions identify some of the potential sources of unaccounted-for water, including water for fire fighting and flushing, leaks and breaks, illegal connections, faulty meters, and other sources.

The Massachusetts Department of Environmental Protection uses a detailed definition provided by a sister agency, the Water Resources Commission, to define unaccounted-for water as: "the difference between water pumped or purchased and water that is metered or confidently estimated. Unaccounted for water should include, meter problems (i.e. master meter inaccuracies, domestic and non-domestic meter under-registration, etc.), unauthorized hydrant openings, unavoidable leakage, recoverable leakage, illegal connections, stand-pipe overflows and data processing errors."

Three state agencies in the sample provide worksheets or formulas for calculating unaccounted-for water. The Missouri Department of Natural Resources defines water loss as a simple percentage: ((water pumped minus water used)/(water pumped)) times 100. Total usage is the sum of customer meter readings, volume used for main flushing or fire hydrant testing, volume sold through water salesman or truck loads from fire hydrants, volume used to fill swimming pools not otherwise metered, etc.

The Texas Water Development Board provides a worksheet for systems to calculate unaccounted-for water, which can be summarized in three steps:[10]

(1) The volume of water produced or supplied to the distribution system, as measured by all master meters at wells and treatment facilities or points of purchase from other utilities, is totaled.
(2) The volume of water sold and distributed as measured by sales meters and estimated un-metered uses.
(3) Unaccounted-for water is obtained by subtracting water sales from total water produced supplied.

[10] Texas Water Development Board, *A Guidebook for Reducing Unaccounted-for Water* (Texas Water Development Board, June 1997), 2.

Texas also defines unaccounted-for water as production minus sales (and the percentage of unaccounted-for water as unaccounted-for water divided by water produced times 100).

The Pennsylvania Department of Environmental Protection defines unaccounted-for water as generally "water which is produced but is not used or sold to the consumers."[11] The percent of unaccounted-for water is then specified in a basic calculation:

Percent of Unaccounted for Water =
(Water Available for Sale) – (Water Sold or Used)/Water Available for Sale x 100

Accounting and Reporting

Most water professionals agree that all water systems, even smaller systems, should implement a basic system of water accounting. AWWA provides a manual, *Water Audits and Leak Detection* (M36, 1990) to guide this process.[12] Water accounting facilitates the process of tracking water throughout the transmission and distribution system—from water sources to end users—and also identifies areas that may need special attention, such as the existence of large volumes of nonaccount water.

The survey indicates that twenty (20) state agencies and the two Florida water management districts either require or provide guidelines for water accounting and/or reporting water loss. Accounting and reporting may be part of an annual report requirement to an agency or may be required as part of an application process. Several examples illustrate the diversity in accounting and reporting.

The Environmental Protection Division of the Georgia Department of Natural Resources requires, as part of a permit to withdraw ground and surface water, submission of an annual water-use data report that includes information on unaccounted-for water for the prior twelve (12) months.

The Iowa Department of Natural Resources Water Supply Section Construction Permit Application requires applicants to provide data for unaccounted-for water (on an average-day and peak-day basis).

In addition to reporting requirements for unaccounted-for water, three state agencies also require a statement of how the utility plans to remedy the situation. In

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[11] Pennsylvania Department of Environmental Protection, *Public Water Supply Manual – Part 5 (Appendix A)*, November 1, 1997.

[12] Several water conservation planning manuals also have suggested systems of water accounting. One that contributed to the method proposed in this article appeared in the *Water Conservation Manual* published by the New York State Department of Environmental Conservation (January 1989).

its Annual Statistical Report for Community (COM) Public Water Systems and Non-Transient Non-Community (NTNC) Public Water Systems, the Massachusetts Department of Environmental Protection requires systems to identify the reasons for the unaccounted-for water, as well as the measures that will be implemented to correct the problem. According to the required form:

> If your system has 15% or greater unaccounted water or uses 100,000 gallons per day or greater and has any % unaccounted for water, please indicate in the table below the possible reason(s) for your unaccounted for water and your plans to correct these problems. Please note that during or before your next Sanitary Survey DEP staff will evaluate your progress with the corrective actions plans as indicated.[13]

In a like manner, the Ohio Public Utility Commission requires each waterworks company to annually report unaccounted-for water and also to propose remedial actions if unaccounted-for water exceeds 15 percent. The West Virginia Public Service Commission also requires a statement of remedial actions to be taken if the utility indicates unaccounted-for water greater than 15 percent in its annual report.

The New York Department of Health requires water suppliers to prepare an annual Drinking Water Quality Report that includes an accounting of the total amount of water withdrawn, delivered, and lost from the system. The Texas Water Board provides detailed worksheets for calculating unaccounted-for water in their Drought Planning Guide. Finally, the Public Service Commission of Wisconsin requires utilities to maintain a ongoing record that compares water pumpage with metered consumption.

Standards and Benchmarks

The imprecision of the definitions of water losses carries over to the establishment of standards and benchmarks. The survey confirmed the lack of clear consensus on standards. Twenty-eight agencies (representing twenty-three states and the three regional authorities) reported the use of some standard or benchmark for water losses. Table 2 presents standards for "unaccounted-for water" from a select number of jurisdictions. The reported standards range from 7.5 to 20 percent, with 15 percent being most common. The percentages refer generally, but rather vaguely, to water losses relative to production.

[13] Massachusetts Department of Environmental Protection, "2001 Public Water System Annual Statistical Report for Community (COM) Public Water Systems and Non-Transient Non-Community (NTNC) Public Water Systems." http://www.state.ma.us/dep/brp/dws/files/comntnc.doc

Table 2
Selected State Standards for Unaccounted-for Water

State	Agency	Standard
Arizona	Department of Water Resources	10% (large) 15% (small)
California	Urban Water Conservation Council	10%
Florida	Southwest Florida Water Management District	12% or less
Florida	St. Johns River Water Management District	10%
Georgia	Environmental Protection Division	Less than 10%
Indiana	Department of Environmental Management	10 to 20%
Kansas	Kansas Water Office	15%
Kentucky	Department of Energy, Water and Sewer Branch	15%
Louisiana	Department of Environmental Quality	15%
Massachusetts	Department of Environmental Protection	15%
Minnesota	Department of Natural Resources	10%
Missouri	Department of Natural Resources	10%
North Carolina	Division of Water Resources	15%
Ohio	Public Utility Commission and Environmental Protection Agency	15%
Oregon	Water Resources Division	10-15%
Pennsylvania	Public Utility Commission	20%
Pennsylvania	Bureau of Water and Wastewater Management	10-15%
Rhode Island	Water Resources Board	10-15%
South Carolina	Public Service Commission	7.5%
South Carolina	Department of Health and Environmental Control	10%
Texas	Water Development Board	10 to 15%
Texas	Natural Resources Conservation Commission	20%
Washington	Department of Health	20% (10% proposed)
West Virginia	Public Service Commission	15%
Wisconsin	Public Service Commission	15% (large) 25% (small)
Delaware River Basin Commission	Delaware River Basin Commission	15%

Source: Survey of states.

According to the review, only Arizona, Texas, and Wisconsin established different standards for water systems based on their type or size. The Texas Water Development Board, for example, has found that "unaccounted for water rates above 15 percent for municipal systems and slightly higher (15% to 18%) for wide-spread rural systems indicate the need for immediate actions."[14]

Goals and Targets

Eighteen (18) state agencies and the two Florida water management districts mentioned a goal or target for water-loss reduction. In most cases the goal or target is for the utility to meet the standard or benchmark for unaccounted-for water discussed in the previous section. Goals often are stated in relatively vague terms.

For example, the Florida Department of Environmental Protection, Water Resource Implementation Rule declares that, "The overall water conservation goal of the state shall be to prevent and reduce wasteful, uneconomical, impractical, or unreasonable use of water resources..."Districts shall further accomplish this water conservation goal by:...3. Minimizing unaccounted for water losses..."[15]

The Minnesota Department of Natural Resources provides a time period target of three years for a water supplier to reduce unaccounted-for water:

> If unaccounted-for water exceeds 20% of total water appropriations the public water supplier's water appropriation permit is amended to require the implementation of measures to reduce unaccounted-for water volumes within 3 years. The generous targets of 20% and 3 years are intended to provide sufficient time and resources for small systems...[16]

The Kansas Water Office is the only agency in the sample to specify a particular target year. The agency plans to reduce the number of public water suppliers with excessive unaccounted-for water by the year 2010.

Planning Requirements

For twenty-seven (27) of the agencies in the sample, water-loss issues are addressed in the context of planning requirements. In almost every case, the planning requirement is for water conservation, supply, or emergency planning. For example, the Connecticut Department of Health requires water suppliers to

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[14] Texas Water Development Board, 2.
[15] Florida Statute, CHAPTER 62-40 Water Resource Implementation Rule 62-40.412 Water Conservation. http://www.dep.state.fl.us/water/rules/62-40.pdf
[16] Jim Japs, Supervisor, Water Permit Programs, MN Department of Natural Resources, Division of Waters, survey information.

discuss current leak detection and repair and pressure-reduction programs in their Water Supply Plans. In Nevada each water supplier must "identify and reduce leakage in water supplies, inaccuracies in water meters and high pressure in water supplies"[17] in its required water conservation plan. In Vermont, the Department of Environmental Conservation requires systems to prepare a water conservation plan that, "at a minimum, addresses the following: (a) evaluation of system water use efficiency, including evaluation of extent of unaccounted-for water, water accounting, and loss control."[18]

The Texas Natural Resources Conservation Commission includes more specific requirements in their water conservation plans:

> All water conservation plans for municipal uses by public drinking water suppliers shall include the following elements: (E) measures to determine and control unaccounted-for uses of water (for example, periodic visual inspections along distribution lines; annual or monthly audit of the water system to determine illegal connections, abandoned services, etc.). For Systems serving 5,000 or more population the plan must include "a program of leak detection, repair, and water loss accounting for the water transmission, delivery, and distribution system in order to control unaccounted-for uses of water" For wholesale water suppliers, plans must include goals for "maximum acceptable unaccounted-for water"[19]

New Hampshire and Virginia require water-loss management plans in connection with all new groundwater withdrawals. The Kansas Water Office requires a water utility to implement a water management review every time the amount of unsold water exceeds 20 percent of the total raw-water intake for a four-month time period.

Compilation and Publication

Only nine state agencies and one Florida water management district appear to compile or publish data on water losses. Two agencies, the Hawaii Department of Water Supply and the Southwest Florida Water Management District compile water loss data but do not publish this information for public consumption. In some states, such as Minnesota, water-loss data is only available through annual reports or planning documents. The Kansas Water Office compiles data on unaccounted-for water and publishes it in the Kansas Municipal Water Use Report, which is available

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[17] Nevada Revised Statutes (NRS), NRS 540.141.

[18] Vermont Environmental Protection Rules, Chapter 21,revised December 29, 2000: Appendix B, Long Range Plan Requirements.
http://www.anr.state.vt.us/dec/watersup/wsrule/WSRuleDecember2000.pdf

[19] Texas Rules, Chapter 288 Subchapter A: Water Conservation Plans 288.1-288.6 Effective April 27, 2000. http://www.tnrcc.state.tx.us/oprd/rules/pdflib/288a.pdf

online. The office currently lists sixty-one (61) systems with unaccounted-for water amounting to 30 percent or more.

Technical Assistance

Eighteen (18) state agencies and one Florida water management district in the sample provide some amount of technical assistance to water utility systems to help reduce water losses. In Kansas, technical assistance is provided to any public water supplier upon request. The Kansas Rural Water Association provides on-site technical assistance at no charge. In Texas, technical assistance, classes, and training are available from a number of providers, including the Texas Natural Resources Conservation Commission, Texas Water Development Board, Texas Water Utilities Association, the Texas Engineering Extension Service, and the Community Resource Group.

The Kentucky Infrastructure Authority implements a program to assist systems in detecting water losses from distribution lines. The program includes both audits and low-interest loans:

> The authority shall establish a program to assist governmental agencies in detecting water loss from distribution lines. The program may include contracting with third parties to conduct water loss audits and leak detection. The program may include giving low interest loans, on a priority basis established by the authority consistent with the findings and purposes set out in section 1 of this act, for the repair or replacement of distribution facilities, deemed reasonable by the authority, undertaken as a result of the water loss audit.[20]

Performance Incentives

Only eleven (11) state agencies and one Florida water management district in the sample indicated the use of performance incentives for water loss reduction, broadly defined for the purpose of this study. Minnesota and Rhode Island consider the approval of a conservation plan or permit as a performance incentive. The Rhode Island Water Resources Board, for example, requires attention to water-loss reduction for approval of Water System Supply Management Plans. The Vermont Department of Environmental Conservation reported that fees might be slightly lowered as incentive for water-loss reduction. The Texas Natural Resources Conservation Commission, a price regulator for some systems, reports that a system's rate of return may be affected by excessive line losses.

[20] 2000 Ky. Acts 529; 2000 Ky. Ch. 529; 2000 Ky. SB 409

Four states (Indiana, Iowa, Louisiana, and North Carolina) mention water losses in their state revolving loan fund (SRF) applications. In some instances, higher rates of water loss might actually result in greater benefits. For example, Louisiana assigns extra points to loan applicants experiencing unaccounted-for water greater than 15 or 25 percent. Although such incentives might appear "perverse," the intention is to identify systems most in need of assistance. Moreover, loan provisions generally require a plan to reduce losses.

Thus, Iowa assigns ten points to SRF applicants that plan to rectify excessive water losses per the established water conservation plan if unaccounted-for water is more than 15 percent. North Carolina's funding programs place a particular emphasis on water losses. The Drinking Water Treatment Fund awards up to 20 points for projects that replace undersized or leaking water lines. For the state's Clean Water Bond Loan Program and Clean Water Revolving Loan and Grant Program, five points are given if "An applicant demonstrates it has a continuing water loss program in its water supply system program."[21]

Auditing and Enforcement

Fifteen (15) agencies in the sample call for some type of auditing or enforcement. Generally, these policies are basic auditing requirements. None of the jurisdictions covered by the survey were found to impose direct sanctions (such as fines) on systems failing to meet water-loss related requirements.

Auditing includes any agency review of the water utility's annual report or planning documents. Utility's might also be required to conduct a periodic water audit. For example, the St. Johns River Water Management District requires all consumptive use permit applicants to complete a water audit, paying special attention to unaccounted-for water:

> If the total unaccounted for loss of the system from line 4F is 10% or greater, the applicant is required to evaluate the feasibility of completing the leak detection survey found on the water audit form. The applicant has the option to perform the leak detection immediately or to propose a one year program to improve water use accountability to below 10% and then to repeat the audit. If the second audit shows unaccounted-for water loss above 10%, the permittee must implement the leak detection program where feasible.[22]

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[21] North Carolina Public Water Supply Section, Chapter 1 - Departmental Rules, Subchapter 1 L - State Clean Water Bond Loan Program Section 0.100 - General Provisions

[22] St. Johns Water Management District, *Instructions for Completing the District Water Audit Form.*

The Minnesota Department of Natural Resources audits annual reports and also requires an audit of unaccounted-for water when reviewing each permit request. Public water suppliers with losses exceeding 20 percent must provide an annual report of actions being implemented to reduce unaccounted-for water. The Kansas Rural Water Association closely audits all public water suppliers with 30 percent or more unaccounted-for water. Quarterly monitoring is required until two consecutive quarterly reports show 20 percent or less unaccounted-for water.

As an example of potential enforcement, the Ohio Public Utility Commission requires a water company to notify the Commission if it cannot comply with water-loss requirements. The company is given thirty days to take corrective actions and submit a report to the Commission. "The compliance division of the commission shall, after reviewing the report, notify the company of any further necessary actions."[23]

Case Studies

Six cases are highlighted here because they represent significant water-loss policy developments at the state and regional levels.

Arizona Department of Water Resources

Most water-loss requirements in Arizona are implemented through the states five Active Management Areas (AMA). Each AMA must submit a yearly Management Plan, which requires all municipal suppliers to report their unaccounted-for water.

Arizona applies a relatively specific working definition of unaccounted-for water:

> Lost and unaccounted for water is defined as the total water from any source, except direct use effluent, withdrawn, diverted, or received in a year minus the total amount of authorized deliveries made by the municipal provider in that year.[24]

Lost and unaccounted-for water includes leaks (from distribution lines, sewer lines, storage tanks, storage ponds, hydrants), breaks (from distribution lines, sewer lines, mains, hydrants), measurement errors (meter under/over-registration, source meter errors, flumes/weirs errors), evaporation, illegal connections/water theft, and phreatophyte uses.[25]

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[23] Ohio Administrative Rule 4901:1-15-22 OAC.
[24] Arizona Department of Water Resources, *Third Management Plan for Phoenix Active Management Area, 2000-2010.*
[25] Ibid.

Arizona is one of only two jurisdictions (along with Wisconsin) that has established different water-loss standards for small and large systems. Small municipal providers are required to maintain lost and unaccounted-for water at or below 15 percent while large municipal providers are required to maintain lost and unaccounted-for water at or below 10 percent. Large systems that are unable to operate and maintain their distribution systems to meet the 10 percent requirement are required to line all canals used to deliver untreated water to delivery points with a material that allows no more lost water than a well-maintained concrete lining.

All municipal providers are required to annually report to the Arizona Department of Water Resources the total quantity of lost and unaccounted-for water during the calendar year, as well as the percentage of water lost and unaccounted for.

Municipal providers also are required to include per-capita usage estimates in their yearly report, the calculation of which considers lost and unaccounted-for water. Lost and unaccounted-for water is calculated accordingly:

1. Subtract the calendar year total residential, non-residential, and system-related deliveries from the calendar year total non-irrigation water use to obtain the lost and unaccounted for water volume, in acre-feet.
2. Divide the lost and unaccounted for water volume by the total non-irrigation water use for the calendar year and multiply the result by 100.
3. If the product from D.1. is *less than* ten percent, the result is the volumetric allotment, in acre-feet, for lost and unaccounted for water for the calendar year; **or** if the product from D.1. is *greater than* ten percent, multiply the total water use for the calendar year by ten percent. The result is the volumetric **Lost and Unaccounted For Water Allotment**, in acre-feet, for the calendar year.[26]

Kansas Water Office

Kansas has one of the most comprehensive programs for unaccounted-for water among the surveyed jurisdictions. The Kansas program for unaccounted-for water is articulated primarily through the state's annual water plan. The Kansas Water Office is mandated by law to "formulate on a continuing basis, a state water plan for the management, conservation and development of the water resources of the state." [27] The planning process is coordinated with various local, state and federal agencies, special interest groups, and the general public:

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[26] Ibid.
[27] State Water Resource Planning Act (K.S.A. 82a-903 *et seq.*).

> The Kansas Water Office defines unaccounted for water as... the amount of water that a public water supplier pumped and/or purchased from other entities; minus all metered amounts (either sold or distributed free). Metered amounts include sales to other public water suppliers; large industrial, bulk or livestock water users; and residential and commercial customers; as well as metered free water (such as swimming pools, golf courses, community buildings, water treatment process, etc).[28]

One of the two primary objectives of the Kansas Water Plan is to, "By 2010, reduce the number of public water suppliers with excessive 'unaccounted for' water by first targeting those with 30 percent or more 'unaccounted for' water."[29] In addition to the focus on systems with very high losses, the plan also targets systems with losses exceeding 15 percent because "15% was the average percent of unaccounted for water for public water suppliers in 1997, and is a reasonable amount for unfinished water."[30]

Water suppliers are required to report their unaccounted-for water in an annual water report. Failure to submit an annual report is subject to a fine and providing false information is considered a class C misdemeanor. Furthermore, most water suppliers are also required to submit a water-conservation plan. One of the long-term water-use efficiency practices required of water utilities is the implementation of:

> ... a water management review, which will result in a specified change in water management practices or implementation of a leak detection and repair program or plan, whenever the amount of unsold water (amount of water provided free for public service, used for treatment purposes, water loss, etc.) exceeds 20 percent of the total raw water intake for a four month time period.[31]

The Kansas Municipal Water Use Report keeps a current compilation of all water losses in the state of Kansas. The annual and average percent of unaccounted-for water for all public water suppliers in the state is compiled and published by the Kansas Water Office.[32]

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[28] The Kansas Water Office, "2010 Objectives Basin Assessment, Unaccounted For Water Assessment." http://www.kwo.org/assess/unaccount/main.html

[29] The Kansas Water Office, "The Kansas Water Plan, Fiscal Year 2003,' July 2001. http://www.kwo.org/kwp/fy2003kwp.html

[30] ibid.

[31] The Kansas Water Office, "Kansas Municipal Water Conservation Plan Guidelines." http://www.kwo.org/reports/1990_WCP_Guidelines/index.htm

[32] This report is available online at http://www.kwo.org/reports/1999_mwur/index.htm.

Kansas is also one of the few states surveyed that operates a program for technical assistance for water suppliers to reduce water losses. The Kansas Water Office funds on-site technical assistance through the Kansas Rural Water Association to suppliers with 30 percent or more unaccounted-for water. Assistance includes leak detection, meter testing and replacement, and bookkeeping reviews. Technical assistance for preparing water conservation plans is also provided to public water suppliers.

Kansas has a strict auditing program for water suppliers with excessive water losses. The Kansas Rural Water Association monitors public water suppliers with 30 percent or more unaccounted-for water on a quarterly basis. Monitoring continues until two consecutive quarterly reports show unaccounted-for water of 20 percent or less.

The Kansas Water Office reports that their water-loss program has significantly reduced the amount of unaccounted-for water in the state. They project that the amount of unaccounted-for water in excess of 15 percent of total water use for Kansas will be reduced by 82 percent by the target year of 2010.[33]

Minnesota Department of Natural Resources, Division of Waters

Minnesota's water-loss policy is implemented in conjunction with the state's requirement for water emergency and conservation plans. System plans must address demand-reduction measures associated with plan and permit approvals, as well as water losses and unaccounted-for water.[34] An approved water emergency and conservation plan is required as part of the Wellhead Protection Plan and for applications to the State Drinking Water Revolving Fund.

Despite the emphasis on the water-loss issue, Minnesota policy is not guided by clear operational definitions. Unaccounted-for water is simply defined as water withdrawals minus water sales. Water loss is one component of unaccounted-for water. According to a state official, water suppliers estimate their own water loss, using methodologies that are "inconsistent and some times questionable."[35]

The Minnesota Department of Natural Resources (DNR) has required annual reporting of unaccounted-for water for communities serving more than 1,000 people since 1994. Because of inconsistent and questionable methodologies for determining unaccounted-for water, the Minnesota DNR has assumed the task of calculating unaccounted-for volumes based on total water withdrawals less water sales.

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[33] The Kansas Water Office, "The Kansas Water Plan, Fiscal Year 2003,' July 2001. http://www.kwo.org/kwp/fy2003kwp.html

[34] See Minnesota Statutes 2001, 103G.291, Subd. 3 a-c. http://www.revisor.leg.state.mn.us/stats/103G/291.html

[35] James Japs, Minnesota DNR Water, survey response.

Minnesota has set a standard for water losses at less than 10 percent. According to the state's water appropriation permit program:

> Cities should establish a goal for unaccounted-for water (the AWWA recommends less than 10 percent) and monitor unaccounted-for water volumes each month or billing period. Water audit, leak detection, and repair programs should be implemented when unaccounted-for water is higher than the goal.[36]

However, Minnesota has set a more lenient target for public water suppliers with high rates of water loss. "If unaccounted-for water exceeds 20% of total water appropriations the public water supplier's water appropriation permit is amended to require the implementation of measures to reduce unaccounted-for water volumes within 3 years."[37] It is believed that this more lenient goal will give small systems a reasonable amount of time and resources to reduce water loss.

The Minnesota DNR audits all annual water-report forms. Furthermore, an audit and evaluation of unaccounted-for water is conducted in connection with each permit request. If a public water supplier exceeds 20 percent unaccounted-for water, the system must provide an annual report of actions being implemented to reduce unaccounted-for water.

Pennsylvania Public Utility Commission and
Pennsylvania Bureau of Water Supply and Wastewater Management

In Pennsylvania, both the Public Utility Commission and the Bureau of Water Supply and Wastewater Management implement policies that address the issue of water loss. The Public Utility Commission, an economic regulatory agency, requires evidence of the reasonableness of unaccounted-for water claims greater than 20 percent. This policy was adopted in a general waterworks rate-case order. According to the order:

> In the future, water companies with experienced unaccounted-for water of more than 20%, should be prepared to demonstrate by way of substantial evidence that their experience is both normal and reasonable. Such evidence may be a combination of engineering, operations or historical testimony and data, but

[36] Minnesota Water Appropriation Permit Program - "Conservation Measures for Water Supply Systems"
http://www.dnr.state.mn.us/waters/programs/water_mgt_section/appropriations/pwsconserve.html
[37] James Japs, Minnesota DNR Water, survey response.

it should consist of something more than unsupported or conclusory opinions by Company witnesses.[38]

The Commission requires regulated water suppliers to submit data that complies with this directive, including a description of leak-survey programs. As part of their annual report to the Commission, systems are required to complete a form on water delivered into the system during the year. The form requires suppliers to report unavoidable leakage in terms of gallons-per-day per mile of main, located and repaired breaks in mains and services, total unaccounted-for water, and percentage of unaccounted-for water.

The Bureau of Water and Wastewater Management in the Pennsylvania Department of Environmental Protection (DEP) also regulates unaccounted-for water. The Public Water Supply Manual explains the department's water-loss policy and specifies the procedures for staff to follow when they review and evaluate public water supplier's Operations and Maintenance Plans.

Although the DEP defines unaccounted-for water simply as water that is produced but not sold or used, some detail is provided about the particular factors that should be considered when assessing unaccounted-for water:

1. The water produced – Is this quantity accurately determined, has the meter been calibrated, does the meter measure all of the water?
2. The water used for water system purposes such as chemical feed water, backwash water, fire hydrant and blow-off flushing – How is each of these uses measured?...
3. The water sold or used by the consumer must be accurately accounted for. A meter testing program should be in place to periodically test the accuracy of the meters. All consumer use must be accounted for...
4. Water used for fire fighting purposes – This water only can be estimated, but some careful calculations by the fire company and the water system can develop a reasonable value.[39]

The calculation of unaccounted-for water involves subtracting the amount of water sold or used from the water available for sale. The DEP recommends using a one-year period for the calculation to mitigate the effects of metering and seasonal variations.

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[38] Pennsylvania Public Utility Order, Dauphin Consolidated Water Supply Company @ R-79050616, July 2, 1981.

[39] Pennsylvania Department of Environmental Protection, Bureau of Water Supply Management, "Public Water Supply Manual – Part V,"
http://www.dep.state.pa.us/dep/subject/all_final_technical_guidance/bwsch/383-3110-111.htm

The Pennsylvania DEP recommends the AWWA standard of 10-15 percent for unaccounted-for water. However, the department also notes the relevance of a number of systems-specific considerations:

1. The age and condition of the system...A range of 35 to 40 percent may be acceptable until funds for replacement of mains is available;
2. The pressure in the system can affect the rate of leakage. Thus high pressure systems may have a higher percentage of unaccounted-for water;
3. The number of customers per mile of main can affect the unaccounted-for water. Therefore, if a system has a high ratio of miles of pipeline to the number of customers, the percentage of unaccounted-for water will increase;
4. Under-registration of customer meters or unauthorized uses can increase the percentage of unaccounted-for water.[40]

Pennsylvania policy also expressly considers the economic value of water losses. The state recommends that systems "Calculate the cost of producing a thousand gallons or one hundred cubic feet of water and then calculate the amount of money which is being 'lost' as unaccounted-for water each month. By identifying this cost, you can justify the cost of the programs to correct the problem."[41] Suggested programs include meter testing, leakage control program that focuses on detection, and record keeping to support a main-replacement program.

These requirements and recommendations are incorporated in the review and evaluation of the Operations and Maintenance Plans that public water suppliers must prepared in accordance with the DEP's drinking water management programs.

The DEP's Water Allocation Permit system also requires systems to implement a continuous water conservation program, which must include an ongoing leakage and loss control program. Permit holders must initiate a study to develop a plan to reduce unaccounted-for water within one year of the date of the permit and reduce losses to 20 percent or less within five years of the date of the permit.

Finally, the DEP provides free leak-detection services to water suppliers that agree to follow program requirements, including a yearly water audit through a partnership agreement with the Pennsylvania Rural Water Association.

Delaware River Basin Commission

The Delaware River Basin Compact was enacted in 1961 to address water-resource issues on a regional basis. The member states include Delaware, New Jersey, New York, and Pennsylvania. The governing commission is composed of

[40] Ibid.
[41] Ibid.

five members, one from each state and one representing the federal government. The Delaware River Basin Commission (DRBC) has wide authority in the area of water-resource planning and management agencies in the basin. This authority extends to water efficiency and such areas as metering, conservation, billing, and water losses.

The DRBC policy on water loss is established in Resolution 87-6 (revised), requiring owners of water-supply systems serving the public to "undertake a systematic program to monitor and control leakage within their water supply system. Such program shall at a minimum include: periodic surveys to monitor leakage, enumerate unaccounted-for water, and determine the current status of system infrastructure; recommendations to monitor and control leakage; and a schedule for the implementation of such recommendations." After the initial submission of a leak-detection and repair plan, systems are required to submit new plans every three years. Plans are submitted to the respective state regulatory agency for review and approval.

The DRBC uses a very simple calculation for water loss. Unaccounted-for water is the difference between the metered ratio and 100 percent. A standard of 15 percent water loss is suggested and systems that exceed this standard may be subject to more frequent reporting. According to one official, "DRBC's regulatory objective is to reduce overall unaccounted-for water to 15 percent or less by 2020."[42]

Water loss is considered an integral part of the DRBC's overall water-conservation programs. All water purveyors planning a new or expanded water withdrawal must submit a water-conservation plan that discusses source metering, service metering, leak detection and repair, and water conservation performance standards. Although the conservation plan provides no specific incentives for implementation, incentives are more direct in connection with withdrawals; new projects, such as new withdrawals, will not be approved until adequate leak detection and repair programs are implemented.

The DRBC does not provide direct technical assistance to water utilities to help reduce water losses. Nor does the commission require detailed water audits or exert substantial enforcement activity. Still, much of the progress in reducing water losses in the Delaware River Basin is attributed to the DRBC regulations.

St. Johns River Water Management District (Florida)

The St. Johns River Water Management District (SJRWMD) requires the issuance of permits for large-volume water users in accordance with the "Permitting of

[42] Jeffrey Featherstone, 'Conservation in the Delaware River Basin," *Journal American water Works Association* (January 1996): 48.

Consumptive Uses of Water" rule.[43] All applicants for a consumptive-use permit must complete a thorough water audit. The water audit requires identification of water losses in the treatment process and in the distribution system. Applicants must identify all water uses, as well as total unaccounted-for water and the percentage of unaccounted-for water.

Conservation is required as part of all consumptive-use permits. In order to obtain a consumptive-use permit (CUP) from the SJRWMD, "all available water conservation measures must be implemented unless the applicant demonstrates that implementation is not economically, technically, and environmentally feasible."[44] Water-loss reduction is a recognized water conservation measure. Permit applicants must also conduct a meter survey to account for and correct meter error if unaccounted-for water is 10 percent or greater based on the initial water audit.

SJRWMD has one of the strictest requirements for leak detection. According to the applicant's handbook:

> An applicant whose water audit...shows greater than 10% unaccounted for water use, must complete the leak detection evaluation portion of Form 40C-22-0590-3. Based upon this evaluation, an applicant may choose to implement a leak detection program immediately or develop an alternative plan of corrective action to address water use accountability and submit a new water audit to the District within two years. If the subsequent audit show greater than 10% unaccounted for water, the applicant must implement a leak detection and repair program within one year unless the applicant demonstrates that implementation is not economically feasible. In all cases, this evaluation and repair program may be designed by the applicant to firs address the areas which are most suspect for major leaks. The evaluation and repair program may be terminated when the permittee demonstrates that its unaccounted for water loss no longer exceeds 10%.[45]

The leakage evaluation must include the following items:

- Potential water system leakage
- Annual potential system leakage
- Recoverable leakage (assumes 50%)
- Production cost per million gallons
- Recoverable savings
- Estimated cost of leak detection survey
- Estimated recovery period

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[43] Florida Administrative Code, Chapter 40C-2.
[44] Florida Administrative Code, Chapter 40C-2.301 (4).
[45] St. John's River Water Management District, *Applicant's Handbook: Consumptive Uses of Water, Chapter 40C-2, F.A.C.* http://www.sjrwmd.com/Excite/index.html.

The consumptive-use permit will not be issued until the applicant addresses water leaks and losses.

Conclusions

The results of the survey and analysis, summarized in Table 3, suggest a fair amount of state and regional policy activity regarding the issue of water losses. However, the prevailing policies are not entirely clear, consistent, or operational. Most of the identified policies are raising much-needed awareness of the loss issue and promoting better accounting and reporting, but most do not necessarily impose consequences through incentive or enforcement mechanisms.

The findings confirm the need to refine the definitions, measures, and standards for evaluating water losses. A uniform approach, advanced and adopted by authoritative organizations in the water industry, could play a vital role in policy development. It is not uncommon for public policies to refer to authoritative sources with regard to technical standards, such as those that might be developed for water losses.

A precursor to further policy development is the establishment of a uniform system of water accounting and the collection of valid and reliable data on water losses. Better accounting will promote a common understanding of the water-loss issue, as well as appropriate benchmarks and standards. Eventually, best practices for water accounting and loss management may emerge and find reflection in water-loss policies, as future surveys might reveal.

Table 3
Summary of Findings

Issue	Jurisdictions	States (n = 43)	Other (n = 3)	Total (n = 46)
Water-loss policy	AZ, CA, CT, FL, GA, HI, IN, IA, KS, KY, LA, MD, MA, MN, MD, NV, NH, NY, NC, OH, OR, PA, RI, SC, TN, TX, UT, VT, VA, WA, WV, WI, WY, DRBC, SWFWMD, SJRWMD	33	3	36
Definition of water loss	AZ, CA, GA, HI, KS, MD, MA, MN, MO, OR, PA, RI, SC, TX, WI, DRBC, SJRWMD	15	2	17
Accounting and reporting	AZ, CA, GA, HI, IA, KS, KY, MD, MA, MN, MO, NY, OH, OR, PA, RI, TX, WV, WI, WY, SWFWMD, SJRWMD	20	2	22
Standards and benchmarks	AZ, CA, GA, HI, IN, KS, KY, LA, MD, MA, MN, MO, NC, OH, OR, PA, RI, SC, TX, UT, WA, WV, WI, DRBC, SWFWMD, SJRWMD	23	3	26
Goals and targets	AZ, CA, FL, GA, HI, KS, KY, ME, MD, MN, MO, NM, OH, OR, PA, RI, TX, WI, SWFWMD, SJRWMD	18	2	20
Planning requirements	AZ, CA, CT, FL, GA, HI, IA, KS, MD, MA, MN, MO, NV, NH, OR, PA, RI, SC, TX, VT, VA, WA, WV, WI, SWFWMD, SJRWMD, DRBC	24	3	27
Compilation and publication	AZ, CA, HI, KS, KY, MN, PA, RI, WI, SWFWMD	9	1	10
Technical assistance	AK, CA, FL, GA, HI, KS, KY, ME, NV, ND, OR, PA, RI, SC, TN, TX, VT, WI, SWFWMD	18	1	19
Performance incentives	CA, GA, HI, IN, IA, LA, MN, NC, RI, TX, VT, SJRWMD	11	1	12
Auditing and enforcement	AZ, GA, HI, KS, MD, MN, NH, OH, OR, PA, SC, TX, WI, SWFWMD, SJRWMD	13	2	15

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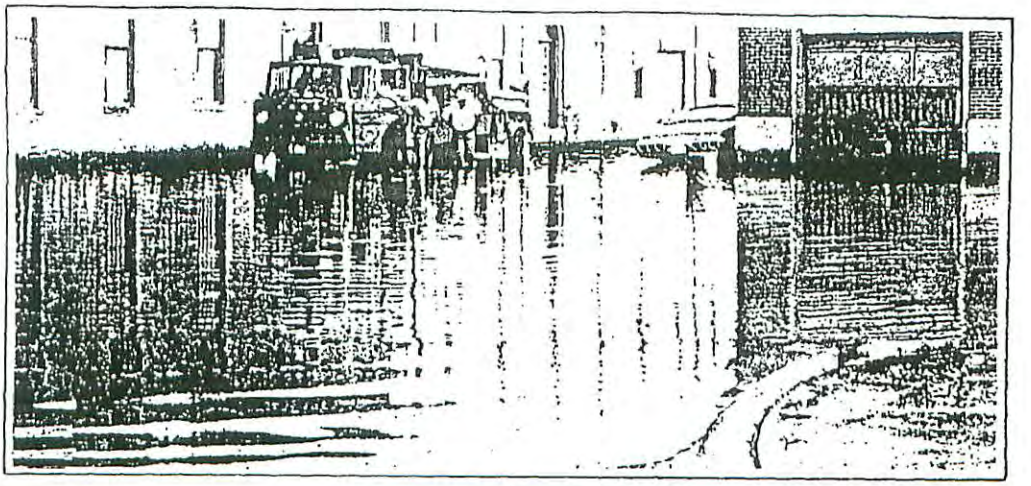
Rebuttal Testimony

Of

Patrick Flynn

Exhibit: AWWA UWL Analysis 1976



Analysis of Unaccounted-for Water

Charles W. Keller

An annual conference paper selected by the JOURNAL authored by Charles W. Keller (Active Member, AWWA), exec. partner, Black & Veatch (Consultant Member, AWWA), Consult. Engrs., Kansas City, Mo.

This article examines statistics on unaccounted-for water based on AWWA's Survey of Operating Data. Comparisons are made of distribution losses for reporting water systems by size, location, ownership, and other variables. Reasons for and causes of unaccounted-for water are also discussed.

The percentage of unaccounted-for water in a system has become a measure of not only the physical condition of the system but of the system management as well. This is understandable when the reasons for unaccounted-for water are examined.

Most water systems meter water pumped to the distribution system, and withdrawn water is measured by a summation of usage through consumers' meters. The difference, with or without further refinement, is usually referred to as unaccounted-for water. Most systems do not meter water used in fighting fires or that used in flushing streets and sewers. Some systems do not meter water furnished without charge, such as that used in parks, municipal buildings, or schools. In reporting unaccounted-for water some utilities estimate known unmetered water use, others do not, thus making such statistics difficult to compare.

Causes

To the layman, the most common assumption is that unaccounted-for water is caused by leakage in the system. Although leakage is probably a principal cause of water loss, it is not the only major reason for unaccounted-for water. Leakage can be controlled within reasonable limits, but probably never completely eliminated.

Incorrect meter reading is another major reason for unaccounted-for water. This can be the result of inaccuracies of either the meters measuring input to the system or the consumers' meters. Several years ago a city had an apparent 37 per cent loss of water pumped to the distribution system. Recalibration of the plant venturi meter reduced this apparent loss by 20 per cent. Conversely a plant meter that underregisters the water pumped to the system can produce extremely low unaccounted-for water statistics.

Under registration of consumers' meter has long been known as a contributor to unaccounted-for water. Since such a deficiency not only causes operating statistics to appear bad and directly affects revenues, an adequate meter-testing and repair program should be a part of every water utility. Practice on customer-meter maintenance varies considerably over the country. Some utilities test and maintain all meters at regular intervals, ten and fifteen years being typical periods, whereas others service only meters that are inoperative. From an economic standpoint the amount of money that can be spent on meter maintenance is related to the value of water sold. A water utility with $1 million-a-year revenue can afford to spend $10 000/year on meter testing and maintenance for each 1 per cent increased accuracy that can be sustained in meter registration. In one city an immediate financial crunch led to the abandoning of a meter-test program that was never reinstituted. The result after several years was that 20 per cent of the residential meters were inoperative.

Unauthorizd use of water by illegal taps and illegal withdrawals from fire lines and hydrants is another source of unaccounted-for water. Detector check meters on private fire lines and vigilance of public hydrants and tapping activity should reduce this cause of loss.

In systems that have any unmetered, or flat-rate customers, the statistics regarding unaccounted-for water are only as good as the estimates made for water use by such customers. If there is any great proportion of unmetered customers in a system, even a small error in estimating customer use can make the statistics invalid.

Record-Keeping

In accounting for water, provision should be made for the following:

1. Care should be taken to be sure that meters measuring water entering the system are properly calibrated and read at frequent regular intervals. If the time period to be analyzed is short, the incoming quantity of water should be adjusted to reflect storage-tank draw down or fill. In longer periods, such as a year, such differences become negligible.
2. Treatment-plant use should be properly metered or estimated and recorded appropriately. A large-plant water use is filter wash water, which should not be overlooked.
3. All regular users of water, whether charged or not, should be metered and read regularly. This not only provides the only accurate method of accounting for water, but also provides a firm basis for declaring the value of free service.
4. Water used in fighting major fires or lost because of major main breaks should be estimated and recorded.
5. Water sold under temporary permits for construction, or to tank wagons, should be metered or estimated and recorded.
6. In calculating percentage of unaccounted-for water, care must be taken to recognize the lag in customer-meter readings as compared with measured quantities entering the system. This is particularly true if the period of calculation is short, such as a month, and the billing frequency is bimonthly or quarterly. In calculating on an annual basis, one should consider that the weight of such factors is less unless there has been substantial growth, or differences in year-end weather conditions from one year to the next. Any changes in billing frequency will affect the calculation unless properly recognized.

Statistical Analysis

For this analysis, statistics have been taken from both the 1965 and 1970 AWWA Surveys of Operating Data. In the 1965 survey data on three categories of nonrevenue producing water were requested: plant use, distribution losses, and free service. A number of utilities did not report nonrevenue water or if so, only in total with no breakdown given. A total of 476 water utilities in the 1965 survey reported distribution losses and were therefore selected for examination. Elimination of systems making no specific report on distribution losses in the 1965 survey resulted in elimination of all data from Alaska, Nevada, Utah, and Vermont.

In the 1970 survey a slightly different form of questionnaire was used. Information requested included quantity of water delivered to the distribution system, metered water sales, and estimated flat-rate sales. A percentage meter ratio was developed by dividing meter water sales by delivery to the distribution system. In the 1965 survey several systems allocated flat-rate water to various revenue water categories, and in the 1970 survey several systems known to have flat-rate customers reported no flat-rate water use. Thus in such cases the meter ratio as reported could not be totally relied upon as a measure of unaccounted-for water or compared directly with the 1965 survey.

For analysis of the 1970 data any system reporting flat-rate use was excluded, and any system with a meter ratio showing 40 per cent, or more losses and no flat-rate use, was examined and excluded if it was known to include unreported flat-rate use. Some systems reported the same quantity of water delivered to the distribution system as metered, obviously misunderstanding the request, and hence were not considered for analysis. These exclusions resulted in 354 water utilities from the 1970 survey being selected for examination. Elimination of systems from the 1970 survey resulted in the elimination of all data from Alaska, Idaho, Rhode Island, and Vermont.

Geographical. The distribution losses of the selected 476 cities from the 1965 survey averaged 9.50 per cent of the total water distributed. The percentage distribution losses were calculated by state, and the states so ranked, as shown on Table 1. This ranking shows Wyoming with the lowest total losses of 1.85 per cent and Louisiana the highest with 27.93 per cent.

The distribution losses from the 354 selected cities in the 1970 survey averaged 10.90 per cent, slightly higher than the 1965 survey. The state averages were calculated and the results shown on Table 2. This ranking shows Colorado with the lowest total losses of 1.33 per cent and West Virginia the highest with 27.60 per cent. No particular geographic pattern is apparent from either survey with states from all parts of the country at various rankings on the list.

Ownership. Distribution losses by type of ownership, public owned or investor, were compared with the following results:

	1965—*per cent*	1970—*per cent*
Government	9.38	10.93
Investor	11.00	10.60

The government-owned systems were 412 in number in 1965 and 354 in 1970, and the number of investor-owned systems totaled 64 in 1965 and 36 in 1970. In both surveys the averages by type of ownership are very close to the overall average, and reverse positions in the two comparisons.

Type of supply. A comparison was made of cities by type of supply, ground or surface, with these results:

	1965—*per cent*	1970—*per cent*
Ground supply	9.60	11.16
Surface supply	9.48	10.79

In both surveys surface supply systems had slightly less than average losses but not in any significant amount.

System size. The distribution loss by size of system was investigated by separating the reporting systems into five categories based on total annual system pumpage. The results are

	1965 No. of Systems	1965 Losses *per cent*	1970 No. of Systems	1970 Losses *per cent*
< 2 000 mil gal/year	259	10.84	212	14.99
2 000 – 5 000 mil gal/year	108	9.85	72	12.23
5 000 – 10 000 mil gal/year	53	9.86	36	11.42
10 000 – 50 000 mil gal/year	45	11.17	28	10.77
> 50 000 mil gal/year	11	8.17	6	9.02

The percentage loss appears generally to be lower as the pumpage increases, the major reversal of this trend in the 1965 survey being the 10 000 – 50 000-mil gal/year group. In reviewing the cities included in that grouping there are two with losses of 33.21 per cent and 23.91 per cent, which, if excluded, would reduce the group average to 9.85 per cent.

Annual revenue. The relationship of size to distribution loss was also measured based on total annual revenue with the following results:

	1965 No. of Systems	1965 Losses *per cent*	1970 No. of Systems	1970 Losses *per cent*
< $ 500 000/year	223	10.62	124	14.90
$ 500 000 – $1 000 000/year	106	10.18	91	13.20
$1 000 000 – $5 000 000/year	108	8.82	113	11.60
$5 000 000 – $10 000 000/year	24	13.29	14	10.02
> $10 000 000/year	15	8.25	12	9.89

TABLE 1

1965 *Survey*
State Rankings in Order of Distribution Loss as a Percentage of Total Distribution

State	Distribution Loss *per cent*	Number of Systems
1. Wyoming	1.85	2
2. Washington	2.91	12
3. New York	3.65	19
4. New Mexico	3.69	5
5. Michigan	3.80	19
6. Montana	4.00	2
7. Colorado	4.67	5
8. Kansas	4.98	7
9. Mississippi	5.30	4
10. Rhode Island	5.52	2
11. Oregon	5.99	6
12. Arkansas	6.20	8
13. Virginia	6.42	8
14. South Dakota	6.58	4
15. Arizona	6.59	3
16. California	7.02	62
17. North Dakota	7.42	2
18. New Jersey	7.48	7
19. Wisconsin	8.28	22
20. South Carolina	8.56	6
21. Oklahoma	9.36	4
22. Massachusetts	9.52	14
23. Nebraska	9.72	5
24. Texas	9.73	23
25. Minnesota	10.18	14
26. Florida	10.23	13
27. Missouri	10.33	9
28. Hawaii	10.38	2
29. Connecticut	10.48	10
30. Delaware	11.00	1
31. Iowa	11.18	10
32. Indiana	11.82	11
33. Georgia	12.68	4
34. Tennessee	13.32	11
35. Maryland	14.13	5
36. Ohio	14.44	28
37. Illinois	14.59	23
38. New Hampshire	16.67	1
39. Kentucky	16.76	10
40. Idaho	16.91	1
41. Alabama	17.16	9
42. Pennsylvania	17.80	37
43. West Virginia	17.82	3
44. Maine	18.19	6
45. North Carolina	27.29	11
46. Louisiana	27.93	6

TABLE 2

1970 *Survey*
State Rankings in Order of Distribution Loss as a Percentage of Total Distribution

State	Distribution Loss *per cent*	Number of Systems
1. Colorado	1.33	1
2. Utah	4.99	1
3. Nevada	5.80	1
4. Mississippi	6.12	2
5. Delaware	6.49	1
6. California	6.62	55
7. Connecticut	7.38	4
8. Washington	7.69	10
9. Wyoming	8.00	1
10. South Dakota	8.22	4
11. North Dakota	9.39	2
12. Virginia	9.42	11
13. Wisconsin	9.86	18
14. Washington, D.C.	9.94	1
15. North Carolina	10.00	4
16. Nebraska	10.10	5
17. Texas	10.48	21
18. Florida	10.57	12
19. New Jersey	11.24	7
20. Michigan	11.26	14
21. Arizona	11.33	6
22. Maryland	11.50	1
23. Georgia	11.73	3
24. Montana	11.79	2
25. Hawaii	12.00	3
26. New Hampshire	12.05	1
27. Indiana	13.24	10
28. Kansas	13.43	13
29. Kentucky	13.96	2
30. Arkansas	14.22	5
31. Oregon	14.32	6
32. South Carolina	15.22	3
33. New York	15.33	18
34. Oklahoma	16.07	1
35. Minnesota	16.64	12
36. Tennessee	16.81	8
37. Iowa	17.38	14
38. Massachusetts	17.43	4
39. Alabama	17.96	6
40. Ohio	17.97	17
41. Pennsylvania	18.25	14
42. Illinois	18.80	15
43. Missouri	19.73	5
44. New Mexico	20.01	4
45. Louisiana	21.29	3
46. Maine	22.44	2
47. West Virginia	27.60	1

The two systems in the 1965 survey with high losses in the 10 000–50 000-mil gal/year pumpage group are also in the $5 million – $10 million revenue range, producing the trend reversal. Again it appears that larger systems have a smaller percentage of loss.

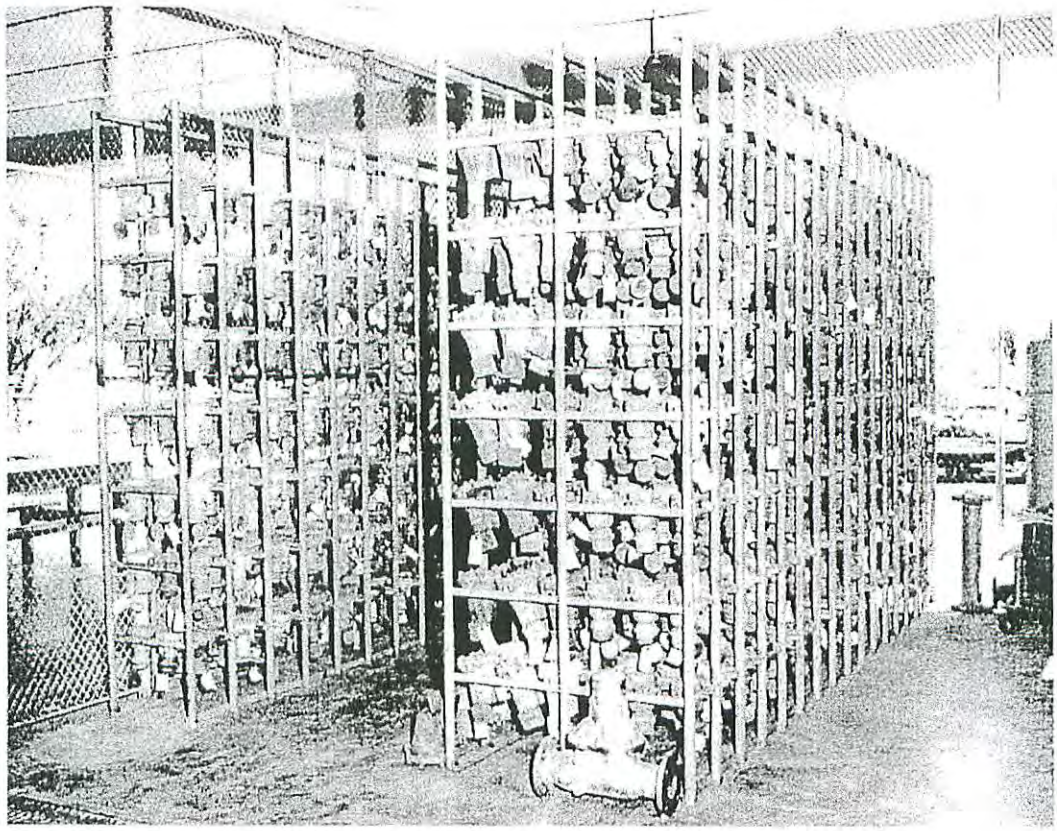
Value of water. To determine if there was any relationship between the unit value of the water lost and the percentage of loss, a comparison was made of the losses by ranges of average unit production cost per thousand gallons with the following:

	1965 No. of Systems	1965 Losses *per cent*	1970 No. of Systems	1970 Losses *per cent*
<20¢/ 1 000 gal	82	8.98	28	9.28
20¢–30¢/ 1 000 gal	167	9.71	80	12.95
30¢–40¢/ 1 000 gal	116	10.33	105	9.27
40¢–50¢/ 1 000 gal	60	11.24	71	12.17
>50¢/ 1 000 gal	51	9.62	70	10.85

If general laws of economics were followed, it would be expected that as a commodity became more expensive, more care would be exercised to prevent its loss, hence the percentage losses would be lower. The tabulation, however, generally indicates the reverse of this. It should be noted that a number of the larger systems have the lower unit production cost; hence it appears that loss prevention may be occurring for reasons other than strict economic benefit. A possible reason might be that larger systems generally pay higher management salaries, and hence attract more competent and experienced personnel.

Ranking. In the study of 1965 data, all 476 water utilities were ranked in order of percentage loss, and the median system was found to be 9.14 per cent as compared with the average of 9.50 per cent. Twenty-five per cent of the systems had losses <4.45 per cent, and 10 per cent had losses <1.43 per cent. Conversely, 25 per cent of the systems had losses >14.65 per cent, and 10 per cent had losses >21.60 per cent.

In the study of 1970 data, the 354 selected utilities were ranked and listed in the same manner, and the median system had losses of 11.63 per cent as compared with the average of 10.90 per cent. Twenty-five per cent of the systems had losses <7.23 per cent, and 10 per cent had losses <4.00 per cent. On



Malfunctioning water meters can be a major reason for unaccounted-for water.

the other end of the scale, 25 per cent had losses >18.37 per cent, and 10 per cent had losses >25.51 per cent.

The data used in this analysis were only a small part of a large quantity of operating statistics, and it is believed that a proper amount of care might not have been exercised by some utilities in compiling the information. The small number of reporting utilities and lack of detail both served to produce a smaller-than-desired universe of data. A further complication exists in that it is known from personal experience that not all utilities keep statistics in the same manner; hence to this degree, like figures are not compared. Examples are known that both overstate and understate distribution losses; however, it is believed that the net effect on the average is to understate losses.

Excessive Loss

It is the author's opinion that systems with distribution losses of < 10 per cent can be rated excellent with 10–20 per cent losses in the reasonable range. If system losses exceed the 20 per cent level, the first thing that should be done is to examine the method of calculations suggested in this article to determine if the loss is real. After ascertaining that an excessive loss exists, the probable major causes should be attacked first. These include under registration of customer meters and major leaks.

Detection of major leaks can be accomplished by various methods, some of which might be peculiar to a given system. Leaks that produce aboveground flow are usually reported, and inspection of storm sewers in dry weather periods may disclose a flow that can be traced to a water-main leak. In this regard it may be desirable to establish a working relationship with local sewer utility personnel regarding their knowledge of extraneous flow. Furthermore, sections of the distribution system can be isolated, and a 24-hr recording made of inflow. Generally, large unexplainable night flows are indications of leaks. Further examination can determine the location and size of the leak with sonar equipment. A number of articles have been written over the years that explain methods of leak detection in more detail than possible in this article. Many utilities effectively employ specialized consultants for such leak-detection surveys.

In checking under registration of customer meters, the investigation should begin first with the large meters. Obviously a 4-in. or 6-in. meter, not properly recording, can account for far more loss than a 5/8-in. meter. Detector check meters on fire lines should also be inspected for unauthorized use. A program whereby meter readers report inoperative meters or meters with substantial consumption reductions can be initiated. If the utility employs computer billing, the billing process can include a listing of all accounts where consumption falls below a designated percentage of the consumption for a like period of the previous year. Such reports require follow-up to determine the reasons for the consumption changes. Any meter maintenance program developed should consider separately and place the most emphasis on the larger meters serving industrial and large commercial customers.

Summary

In summary it is a basic truth that unaccounted-for water will always exist in water utilities. This fact may not be understood by laymen. However, good management can keep the quantity within reasonable limits.

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